

Testing Combination Systems CSA P.9 “The Not-So Surprising Results”

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Learning Objectives for this session

- Define combination systems, their components, and good application opportunities
- Describe the design process for combo systems and methods to maximize their efficiency in both space and hot water applications
- Provide information about the necessary trade-offs between very high efficiency and user comfort
- Discuss different types of combo systems and their applications
- Explain current test methods and opportunities to improve them
- Discuss the necessary specifications to ensure a successful combo installation and the difficulties in installing these systems

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Outline

- Why we need a new standard
- Comparison to ASHRAE SPC 124
- Further requirements for P.9
- Results of initial testing to P.9
- Further testing planned

Background

- Combos filled a market gap for low heating outputs
- Growing Market
- No way to determine combined performance

Why do we need P.9?

- Testing combos as an operating system, not individual components
- Need to evaluate the complete system and recognize performance interactions and synergies
 - Smart integration
 - Advanced controls

Issues with component based testing

- Individual components tested and rated separately
 - Current component based Standards approaches
 - May be rated under unrealistic conditions
 - Synergies and smart controls not recognized
- Different test conditions
 - Difficult to combine ratings into an overall rating

Component Level Approach

- Analogous to rating a furnace by evaluation of it's sub-components:
 - Controls
 - Blowers
 - Burner
 - Heat exchanger

P.9 vs. other methods

- Tests and rates at the conditions in which the system operates, as opposed to being tested to current test methods that are strictly applicable to that component
- Doesn't force set points, which allow manufacturers to be creative with controls
- Part load efficiency in space heating mode

CSA P.9-11

Test method for determining the performance of combined space and water heating systems (combos)

P.9 definition of a combo

- Product or groups of individual components that form an integrated system that is designed to provide the functions of space and water heating
- Use water as the heat transfer fluid
- Heat generator - gas or oil-fired boiler or water heater
- An air handler or fan coil for space heating
- Controls integrated into package

Scope of Combo Standard

- Type A System: a combo with a fixed capacity for space heating;
- Type B System: a combo equipped with controls that automatically adjust the space heating capacity based on the space heating load; and
- Type C System: a combo with a thermal storage tank or equivalent that decouples the space heating load from the burner control.

What P.9 does not cover

Does not apply to

- Hydronic distribution
 - Future work for P.9
- electric and solar-based combo systems;
- solid-fuel-based combo systems; and
- multi-family dwellings with a central heating plant

Overriding Principles

- Overall performance factor needs to aggregate performance in each operating condition
- Controls need to be operational during performance testing
- Space heating needs to include part-load fractions
- Consistent set-ups required where equipment functions need to be fully operational during all tests

Principles continued

- Technology neutral
 - Boiler based
 - Hot water heater based
- Fuel neutral
 - Oil or gas

P.9 Performance Descriptors

- Thermal Performance Factor (TPF)
- Composite Space Heating Efficiency (CSHE)
- Water Heating Performance Factor (WHPF)
- 1 hr Water Delivery Rating (OHR)

Space Heating

- Input-Output air enthalpy approach
- Part load testing and rating based on load-weighted performance measurements
- Part load space heating cyclic tests
 - 40%
 - 15%
 - Full load output
- $CSHE = 0.1 \times \text{Eff}(100\%) + 0.6 \times \text{Eff}(40\%) + 0.3 \times \text{Eff}(15\%)$
- Takes into account the energy input delivered to the airstream

Water Heating

- Water enthalpy method
- 24 hr simulated use test to determine recovery efficiency
- Combo capacity as a water heater determined and reported as a one hour rating
- Additional capacity testing done with and without concurrent calls for space heating

DHW Capacity

- With and without concurrent call for space heat

Overall Rating

- Thermal Performance Factor (TPF)
 - Sum of annual thermal outputs delivered by the combo for space and water heating divided by the total thermal energy inputs needed to produce each component load
 - Resulting equation:
 - TPF = $\frac{2000H_{CAP} + 4400}{[2000H_{CAP}/CSHE] + [4400/WHPF]}$

Technologies tested?

- Combo 1: Power vented non-condensing storage tank coupled with air handler with ECM
- Combo 2: Power vented condensing commercial storage tank coupled with same air handler as Combo 1
- Combo 3: Manufactured unit

Combo 1: Conventional tank

- Nominal Burner Input 40,000 Btu/h
- Rated storage capacity 50 US gallons
- Rated recovery efficiency of 82%
- Rate EF of 0.68
- Intermittent pilot and electronic ignition
- Paired with a packaged combo air handler with ECM with a rated heating capacity of 48,000 Btu/h

PERFORMANCE RATING									
Thermal Performance Factor (TPF)		0.67							
Annual Electrical Consumption (AEC)		1513 kWh							
Function-Based Performance Ratings									
Space Heating	CSHE	59 (%)	Space Heating Capacity	7 kW					
Water Heating	WHPF	0.56	One Hour DHW Delivery Rating (OHR)	286 L					
Recovery Efficiency		71 (%)	OHR (seasonal efficiency)	289 L					
Thermal standby loss - Circ fan off		226 W							
Thermal standby loss - Circ fan on		133 W							
Selected Test Results									
Space Heating @ PLF 1	Heat Efficiency	54 (%)	Average Electricity Use	692 W					
Space Heating @ PLF 0.4	Heat Efficiency	56 (%)	Average Electricity Use	59 W					
Space Heating @ PLF 0.15	Heat Efficiency	55 (%)	Average Electricity Use	86 W					
			Standby Power (P _{stand})	26 W					
			Standby Power (P _{stand})	9 W					
* Measured with blower running									
Consumer Space & DHW Test Results									
Water Drawn at 49.3°C with & without concurrent call for heat									
Flow (l/min)	Time to reach temperature (min)	Time within 3°C tolerance (min)	Space Heating	Daily Electricity use for water heating (kWh/year)					
	with	without heating call	with	0.51 kWh					
3	0.2	0.2	Indefinite						
15	0.2	0.2	7.5 14.5	Annual electricity use for water heating (kWh/year)					
				187 kWh					
Description of Major Combo Components									
Fancoil: Hot water air handler									
Heat Generator: Power direct vent, 50 US Gallon storage-type water heater. No side connections for space heat									
Blower/Motor: Air handler incorporates a GE 1/2 HP, High Efficiency EC Motor									
Other: Air handler incorporates an integral pump									
Test Agency Comments:									
Storage tank thermostat set to cut-out at an average temperature of 130°F (54°C) for all tests			Filter Rating	not installed, MERV					
Circulating blower in 'auto' mode unless otherwise specified			Segregated DHW System	Yes x No					
Air handler controls include pump, booster for 30 sec. in a 24 hr. period if no demand for space heating			Water Circulation	x Yes No					
Conversion factors			DHW Priority	Yes x No					
248 Pascals = 1" of water			1 kW = 3413 Btu/h	Reference Report 10-05-M01-44.1					

Comb 2: Condensing Storage Tank

- Nominal Burner Input 76,000 Btu/h
- Rated storage capacity 50 US gallons (lab-tested capacity 48.3 gallons)
- Rated recovery efficiency of 85% (compared with rated thermal efficiency of 90%)
- Intermittent pilot and electronic ignition
- Paired with a packaged combo air handler with ECM with rated heating capacity of 48,000 Btu/h

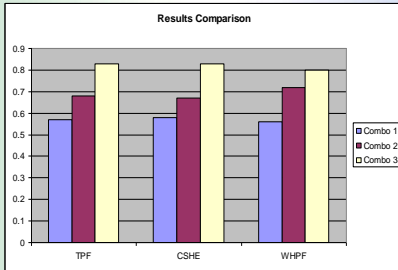
PERFORMANCE RATING									
Thermal Performance Factor (TPF)		0.68							
Annual Electrical Consumption (AEC)		873 kWh							
Function-Based Performance Ratings									
Space Heating	CSHE	67 (%)	Space Heating Capacity	7 kW					
Water Heating	WHPF	0.72	One Hour DHW Delivery Rating (OHR)	543 L					
Recovery Efficiency		85 (%)	OHR (seasonal efficiency)	491 L					
Thermal standby loss - Circ fan off		129 W							
Thermal standby loss - Circ fan on		108 W							
Selected Test Results									
Space Heating @ PLF 1	Heat Efficiency	76 (%)	Average Electricity Use	591 W					
Space Heating @ PLF 0.4	Heat Efficiency	69 (%)	Average Electricity Use	54 W					
Space Heating @ PLF 0.15	Heat Efficiency	61 (%)	Average Electricity Use	67 W					
			Standby Power (P _{stand})	24 W					
			Standby Power (P _{stand})	4 W					
* Measured with blower running									
Consumer Space & DHW Test Results									
Water Drawn at 49.3°C with & without concurrent call for heat									
Flow (l/min)	Time to reach temperature (min)	Time within 3°C tolerance (min)	Space Heating	Daily Electricity use for water heating (kWh/year)					
	with	without heating call	with	0.3 kWh					
3	0.2	0.2	Indefinite						
15	0.2	0.2	6.7 11.1	Annual electricity use for water heating (kWh/year)					
				110 kWh					
Description of Major Combo Components									
Fancoil: Hot water air handler									
Heat Generator: Power vent, condensing, 50 US Gallon storage-type water heater. Side connections for space heat									
Blower/Motor: Air handler incorporates a GE 1/2 HP, High Efficiency EC Motor									
Other: Air handler incorporates an integral pump									
Test Agency Comments:									
Storage tank thermostat set to cut-out at an average temperature of 130°F (54°C) for all tests			Filter Rating	not installed, MERV					
Circulating blower in 'auto' mode unless otherwise specified			Segregated DHW System	Yes x No					
Air handler controls include pump, booster for 30 sec. in a 24 hr. period if no demand for space heating			Water Circulation	x Yes No					
Conversion factors			DHW Priority	Yes x No					
248 Pascals = 1" of water			1 kW = 3413 Btu/h	Reference Report 10-05-M01-44.2					

Combo 3: Manufactured Unit

- Nominal Burner Input 150,000 Btu/h
- Instantaneous condensing water heater
- Modulating input burner 6:1
- DHW priority control
- Segregated DHW supply

PERFORMANCE RATING			
Thermal Performance Factor (TPF)	5.83		
Annual Electrical Consumption (AE)	1173 kWh/yr		
Function-Based Performance Ratings			
Space Heating	CSHE	83 (%)	Space Heating Capacity 13.5 kW
Water Heating	WHWF	0.8	One-Hour DHW Delivery Rating (CHD)
Recovery Efficiency		81 (%)	CHR 920 L
Thermal standby loss - Circ fan off		n/a W	CHR (maximum water loss)
Thermal standby loss - Circ fan on		n/a W	920 L
Selected Test Results			
Space Heating @ PLF 1	Nat. Efficiency	86 (%)	Average Electricity Use 399 W
Space Heating @ PLF 0.4	Nat. Efficiency	84 (%)	Average Electricity Use 153 W
Space Heating @ PLF 0.15	Nat. Efficiency	81 (%)	Average Electricity Use 107 W
			Standby Power (P(stand)) 28 W
			Standby Power (P(peak)) 7 W
			* Measured with blower running
Component Ratings & Data: Test Results			
Water Drawn @ 40 gpm with & without concurrent call for heat			
Flow	Time to reach temperature (minutes)	Time within 43°C tolerance (minutes)	Daily Electricity Use for water heating (kWh/yr)
			0.3 kWh
	with/without heating coil	with/without heating coil	
3	0.2 / 0.2	Indefinite / Indefinite	
15	1.2 / 1.2	Indefinite / Indefinite	
Annual electricity use for water heating (AE _{WH}) 106 kWh			
Description of Major Combo Components			
Commercially available packaged combo system			
SE 3/4 H.P. High Efficiency EC Motor			
Grundfos LP15-42 Pump			
Honeywell A4-5 Series Thermostatic-Mixing Valve			
Test Agency Comments:			
All tests performed at "Heat Prohibit" (PFI) setting on Fan Control	Filter Rating	not installed	MERV _____
Fan Control Storage Feature Timer set to OFF	Segregated DHW System	Y	Yes _____ No _____
Circulating blower in "water" mode unless otherwise specified	Water Circulation	_____	Yes _____ No _____
Heating intake: 2" absorption leak, 3" ARII pipe x terminal Exhaust - 3D equivalent test, 3/8" pipe x terminal	DHW Priority	_____	Yes _____ No _____
Dimensions	Reference Report: 10-08-M0144-3		
140 Pounds ± 1" of Water	1 kW = 3413 Btu/h		

Test Results



Next Steps

- Further testing of different heat generators:
 - Tankless water heater
 - Condensing tankless water heater
 - Boilers
- Inclusion of testing for hydronic distribution systems

QUESTIONS